RESEARCH ARTICLE
SOME IMPORTANT ATTRIBUTES WHICH REGULATES THE LIFE OF MACRO-INVERTEBRATES: A REVIEW
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ABSTRACT
Aquatic habitats are known to support an extraordinary array of species. Aquatic biodiversity is one of the most important characteristics of the aquatic ecosystem for maintaining its stability and resilience. The macro-invertebrates have been found as the most common faunal assemblages for bioassessment and provide more reliable assessment of long term ecological changes in the quality of aquatic system compared to its rapidly changing physico-chemical characteristics. This review discusses some of the factors which regulate the occurrence and distribution of macro-invertebrates namely substrate, temperature, dissolved oxygen and water velocity & current.

INTRODUCTION
The objective of the present review is to examine the literature and summarize the responses of ecological components in particular macro-invertebrates. Studies included in this review range from peer-reviewed literature to un-refereed reports. The focus of the review is the effect of substrate, temperature, dissolved oxygen and water velocity on macro-invertebrates composition and their response to stress. Benthic macro-invertebrates perform a variety of functions in freshwater ecosystem they have an important influence on nutrient cycle, primary productivity, decomposition and translocation of material (Wallace and Webster, 1996; Covich et al., 1999). They are the most commonly used for bio-monitoring in lotic habitat worldwide (Bonada et al., 2006). They play an important role in the mineralization and recycling of organic matter and are an important tool for improving and preserving water quality (Bilgrami and Dutta Munshi, 1985; Venkateswarlu, 1986). It serves not only as a major source of food for fishes but also helps in processing relatively large amounts of organic matter. Alteration produced in the physical and chemical status of the riverine ecosystem becomes recognizable through elasticity of the community structure of the organisms (Wilhm & Dorris, 1968; Cairns & Dickson, 1971). Thus, benthic macro invertebrates make ideal subject for biological assessment of water quality (Hynes1970). Benthic aquatic macro-invertebrates are sensitive indicators of environmental changes in streams because they express long-term changes in water and habitat quality rather than instantaneous conditions (Johnson et al., 1993). Biological indicators are commonly used to evaluate and characterize the ecological changes in streams (Bonada et al., 2006). Among the various biological indicators (such as algae, periphyton, macrophytes, benthic invertebrates and fish), benthic macro invertebrates are the most commonly used biotic assemblage across the world (Rosenberg and Resh 1993; Resh 2008). Macro invertebrates have a number of advantages, and some disadvantages, as indicators of water quality. Advantages of using macro invertebrates include: relatively limited movement, thus reflecting local conditions; diverse communities composed of species that exhibit varying tolerances to changes in water quality and habitat conditions; integration of short-term changes in environmental conditions as reflected in their abundance, diversity, and life cycles; assessment of food web changes (macro invertebrates often serve as important foods for other wildlife, such as fishes and birds); and sampling is relatively easy in terms of requiring few people and inexpensive gear. Disadvantages of macro invertebrates include: difficulties in identification of taxa; effort required to process field samples (e.g., separation of animals from sediments and detritus); and lack of detailed knowledge of life cycles and environmental tolerances, particularly for local populations. Ward and Stanford (1979) also suggested that water flow, temperature and substrates are the major factors determining the composition and abundance of benthic invertebrates. Lot of work is done on lotic ecosystems in India by several workers such as Kulshreshtha el al., (1988); Krishnamoorthy and Sarkar (1979); Khan (1982) and Shukla et al., (1989), Mitra and Nandi (1998); Sharma (1986); Sharma et al., (2004, 2008,2009); Joshi et al., (2007); Sharma and Chowdhary (2011); Habib and Yosuf (2012); Mishra and Nautiyal (2012);Palit et al., (2013).

Factors that governs the occurrence of macro invertebrates
Sediment
Rivers play a paramount role in shaping the landscape by selectively eroding, transporting and depositing sediments on the land in their journey towards the ocean (Lemly,1982) Bed sediments are the primary component of the substrate upon which benthic macro invertebrates move, rest, shelter, and feed. These sediments range from fine clays up to large boulders. From smallest to largest, they are categorized in clay, silt, sand, pebbles,
The substrate type is one of the most important factors which determine the quality and quantity of macro-invertebrates or zoobenthos. Negi and Singh (1990) studied the substratum of the river Alaknanda by Badola and Singh (1981). Substratum is one of the most important factors which determine the quality and quantity of macro-invertebrates or zoobenthos. Negi and Singh (1990) studied the substratum of the river Alaknanda and found that density of macro-invertebrates was higher on the site where large stones and boulders were observed whereas density was low where pebbles were reported and extremely low where the substrate was sandy soil with few pebbles. Hynes (1970) stated that large stones form more complex substratum and hence more diversified fauna. Sharma et al. (2009) studied the shelfal ecosystem of the Tons River and found that bottom substrates ranging from sand to big boulders. Silt and clay were totally absent in the Tons River. High abundance of Macro-invertebrates at the site which has high macrophyte growth and big boulders. Generally, as the size of the stone increases, the diversity of macro-invertebrates also increases; but these bottom dwelling organisms fail to avail themselves of shelter under very large boulders and struggle for their survival due to the unavailability of suitable niches. Sharma et al., (2004) examined the macro-invertebrate diversity in Nanda Devi Biosphere Reserve and found the minimum abundance and diversity at a site where maximum contribution of bottom substrates was by big boulders. Mostly, the group Arthropoda commonly dominates at the sites where bottom substrate is rich in Hard Stone (Emere and Naisru, 2007; Arimoro et al., 2007). The same result found in Yousmarg streams (Habib and Yosuf, 2012).

**Temperature**

Temperature, the most important parameter that influences the life cycle of macro-invertebrates. (Resh et al., 1988). Temperature is the most apparent factor which effects the seasonal cycle and abundance of macro-invertebrates (Elliot, 1967; Macan, 1970). The benthic macro-invertebrates are compatible within a specific temperature range, which restrict them in their distribution and community structure (Hynes, 1960; Biggs et al., 1990). More shallower the water body, more will be the effect of atmospheric temperature (Welch, 1952). It is due to shallowness of Tawi River greatly affects by atmospheric temperature. Annelids showed positive correlation with air temperature (Sharma and Chowdhary, 2011) whereas Ishaq and Khan (2013) found negative correlation between macro-invertebrate density and temperature. Temperature affects emergence patterns, growth rates and body size (Sweeney and Schnack, 1977), metabolism (Angelier, 2003), reproduction (Vannote and Sweeney, 1980) of macro-invertebrates. The tolerance of temperature variation varies species to species but only few are able to tolerate temperatures beyond their upper tolerance limit (Coutant, 1962; Angelier, 2003). Diversity of macro-invertebrates decreases as water temperature increases (Palit et al., 2013). Water temperature was found to be negatively correlated with the diversity of macro-invertebrates in the river Dhauliganga (Sharma et al., 2004). Several studies have also found that particular group of insect richness may be influenced within the same stream ecosystem by annual water temperature variations (Stanford and Ward, 1982). Lehmkulh (1972) studied the influence of water temperature variations on benthic communities. Ward and Stanford (1979) also suggested that temperature pattern influences the life cycle phenomenon of insects such as emergence, which leads to an increase in density. Relationship between the mean density of macro-invertebrates and water temperature was also found to be negatively correlated of Tons River (Sharma et al., 2009). Reduced growth efficiency at very low temperature may eliminate species even though the temperature is within the tolerance range of the organisms (Edington and Hildrew, 1973).

**Dissolved Oxygen**

Dissolved oxygen, a barometer of the ecological health of the river, is the most important parameter for protecting aquatic life (Chang, 2002). Decreased levels of dissolved oxygen influence benthic macro-invertebrate assemblages (Ward, 1992). Dissolved oxygen values are generally low in downstream areas where flow of water is also low so that macro-invertebrate diversity is also lowest (Bredenhand and Samways, 2009). The deficiency of oxygen may affect macro-invertebrates in several ways (Jacobsen, 2003) The maximum density of macro-invertebrates during winter season when Dissolved oxygen is high rather than the monsoon season when the level of dissolved oxygen is low due to high turbidity (Ishaq and Khan, 2013; Negi and Mamgain, 2013). Macro-invertebrate diversity showed a positive correlation with dissolved oxygen (Sharma et al., 2009). Higher dissolved oxygen level in open water habitats is necessary for substantive growth of macro-invertebrate populations. Decrease in the quantity of oxygen and organic matter with increasing depth results in a lowering of biodiversity (Bretschko and Klemens, 1983). Nelson et al., (2000) have also shown that dissolved oxygen has a strong influence on macro-invertebrate community structure.

**Water Velocity and Water Current**

High flow events have been identified in many studies to greatly reduce the biomass and change the species composition of invertebrates in aquatic ecosystems. Change in the frequency of maximal and minimal velocities influenced the density and number of taxa of macro-invertebrates. Reduced flow may result in extreme temperatures detrimental to the benthos. The degree of flow constancy appears to largely determine macro-invertebrate abundance in regulated streams (Ward, 1976; Ward & Stanford, 1979). Many aquatic populations living in the harsh environment of unpredictable flow suffer high mortality from physiological stress (Cushman, 1985). The diversity of macro-invertebrates of Dahuli Ganga river was highly negatively correlated with water velocity. (Sharma et al., 2004) Ermans and Mahoney (1983) and Kamlber (1967) also analyzed the results of flow regime on macro-invertebrate communities. Change in the frequency of maximal and minimal velocities influenced the density and number of taxa of macro-invertebrates. Current is the most important characteristic of running water that decide the adaptation of
macro-invertebrates. Consequently, patterns of colonization differ among streams that differ in flow regime because of inherent differences in benthic community structure (Poff and Ward, 1989). Particularly, near bed hydraulic variables are the key factors to analyse spatial distribution patterns of macro-invertebrates (Brooks et al., 2005; Suren and Jowett, 2006). Therefore, relating impacts of flow regulation to the microhabitat heterogeneity is essential for understanding the effects of flow on fluvial assemblages (Fagan, 2002). Benthic invertebrates are particularly sensitive to different water velocities and bed sediment/stability (Minshall, 1984; Stevenson, 1996). High flow events have been identified in many studies to greatly reduce the biomass and change the species composition of invertebrates in aquatic ecosystems. Many aquatic populations living in the harsh environment of unpredictable flow suffer high mortality from physiological stress (Cushman, 1985). Erman and Mahoney (1983) and Kamler (1967) also analyzed the results of flow regime on macro-invertebrate communities. The study on Tons river (Sharma et al., 2009) confirmed that high water velocity during the monsoon season influenced the macro-invertebrate density and diversity due to the unpredictable flow regime.

CONCLUSION

This review highlights very strong evidence that distribution of macro-invertebrates is governed by numerous physical, chemical and biological factors which need to be taken into consideration in any study of macro invertebrates. The benthic macro-invertebrate community contributes immensely to the functioning of the freshwater ecosystem. Macro-invertebrates act as bio indicator that helps in assessing the health of water bodies. Macro-invertebrates are abundant in many freshwater ecosystem, long-lived compared to algae, possess varying tolerances to perturbations in streams, and are cost-effective to sample, making them an ideal biological indicator. These findings showed that the numbers, density, diversity and the activities of macro-invertebrates are dependent on the substrate, temperature, dissolved oxygen and water velocity.

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References


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